

REVISION OF THE HAWAIIAN SPECIES OF SANTALUM (SANTALACEAE)
HAWAIIAN PLANT STUDIES 109

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ABSTRACT: Based on their morphology, the Hawaiian species of Santalum (Santalaceae) are revised, and including eight species and two varieties. New are S. involutum and S. majus of Kauai.

The genus Santalum is a noteworthy element in the flora of the Pacific Islnds. It was discovered in 1778 that trees of Santalum, with desirable fragrant wood, occurred in extensive groves in the Hawaiian Islands. The logs were felled, cut, and transported to the sea ports. For three decades they furnished a very profitable article of export. Harvested by the people, sold by the king and the chiefs, they were the first article of international commerce exported from the islands. In a single year, the amount realized from this export was \$400,000. This intensive exploitation soon brought the sandalwood trees to the vanishing point.

The first botanist to study and publish on Santalum in Hawaii was Charles Gaudichaud of the French expedition on the Uranie. He collected, described, named, and published (1829) S. Freycinetianum, and S. ellipticum, both from Oahu.

Hooker and Arnott (1832: 94) described a species from the island of Hawaii as S. paniculatum.

Asa Gray (1860: 326-327) accepted Gaudichaud's two species; reduced S. paniculatum H. & A. to varietal status and renamed it as S. Freycinetianum, var. latifolium Gray; and described the Kauai species as S. pyrularium Gray.

Heinrich Wawra (1875: 171) accepted Gray's treatment.

William Hillebrand (1888: 388-391) accepted three species and four varieties. These were S. pyrularium Gray, S. haleakalae Hbd., S. Freycinetianum Gaud., and var. latifolium Gray, var. ellipticum (Gaud.) Hbd., var. cuneatum Hbd., and var. littorale Hbd.

The first local monograph was by Joseph F. Rock (1916), and it was based on his field knowledge, and taxonomic study. He accepted nine species and two varieties of which four species and two varieties were new.

C. Skottsberg (1927) again monographed the local species, and during his studies he was the first to examine the type specimens of the known taxa.

His total was eight species and three varieties. Of these one species and three varieties were new.

L. Stemmermann (1981) made a revisional study of the genus in the Hawaiian Islands, accepting four species and five varieties. She included a key, an enumeration of the taxa, and synonymy. Of the varieties, one is a new combination, the other a novelty and for it there is a description and the listing of specimens.

There have been several smaller publications on Santalum, but the three monographs mentioned above are the important ones. The fact that in each of these three the taxonomy is quite different, shows that Santalum in Hawaii is diverse and that its classification is difficult. The systematic scheme here presented is based on all three previous ones, as well as on the author's field experience and study of herbarium specimens. It differs from Stemmermann's in the recognition of more species, in the relocation of S. Freycinetianum, var. auwahiense; in the reduction of S. ellipticum, var. littorale; and in the recognition of two new species on Kauai, S. involutum and S. majus.

This new classification accepts eight species and two varieties.

The introduced species, S. album L. is not herein treated.

Key to Species and Varieties

- A. Floral tube cylindrical to campanulate, longer than wide,
 - B. Inflorescence terminal, dense, the bracts to 5 mm in length, persisting; blades coriaceous, elliptic to suborbicular. E. Maui. S. haleakalae.
 - B. Inflorescence axillary (or terminal),
 - C. Floral tube campanulate (or short cylindrical); blades mostly lanceolate, conduplicate and falcate, (rarely elliptic and plane).
Oahu, Molokai. S. Freycinetianum.
 - C. Floral tube cylindrical,
 - D. Blades glaucous below, elliptic to suborbicular. Lanai, Maui. . . . S. lanaiense.
 - D. Blades not glaucous,
 - E. Flowers 16-19 mm long, the lobes 5-6 mm long; dried fruit 13 mm long; blades elliptic, flat, 20-36 mm wide. Kauai. S. majus.
 - E. Flowers 8-15 mm long,
 - F. Flowers 8-12 mm long, the lobes 3-4 mm long,
 - G. Blades linear elliptic, mostly folded or rolled; dried fruits 18-20 mm long. Kauai. S. involutum.

- G. Blades lanceolate to lance ovate or elliptic, mostly flat; dried fruits 7-12 mm long. Kauai.
S. pyrularium, var. pyrularium.
- F. Flowers 12-15 mm long, the lobes 5-7 mm long; blades lanceolate to ovate, flat or folded; dried fruits 12-14 mm long. Kauai.
S. pyrularium, var. sphaerolithos.
- A. Floral tube funnellform,
 H. Blades glaucous below; flowers 4.5-5 mm long.
 Hawaii. S. paniculatum, var. paniculatum.
- H. Blades green on both sides,
 I. Flowers 7-8 mm long. Hawaii.
S. paniculatum, var. Pilgeri.
- I. Flowers 4-7 mm long. Main H. I. and Laysan.
 S. ellipticum.

Enumeration of Taxa

- Santalum ellipticum* Gaud., Voy. Uranie Bot. 442, 1829.
- S. album L., var. ellipticum (Gaud.) Meurisse, Soc. Linn. Paris, Bull. 2: 1,025-1,027, 1892.
- S. Freycinetianum Gaud., var. cuneatum Hbd., Fl. Haw. Is. 389, 1888.
- S. Freycinetianum Gaud., var. littorale Hbd., Fl. Haw. Is. 390, 1888.
- S. Freycinetianum Gaud., var. ellipticum (Gaud.) Gray in Mann, Am. Acad. Arts Sci., Proc. 7: 198, 1867.
- S. cuneatum (Hbd.) Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 37, pl. XI, 1916.
- S. cuneatum (Hbd.) Rock, var. laysanicum Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 39, pl. XII, 1916.
- S. littorale (Hbd.) Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 41, pl. XIII, 1916.
- S. cuneatum (Hbd.) Rock, forma gracilius Skotts., (as var. in error), Bishop Mus., Bull. 43: 59, 1927, (see his pp. 56 and 57).
- S. ellipticum Gaud., var. littorale (Hbd.) Skotts., (as littorale), Bishop Mus., Bull. 43: 55, 1927.
- S. ellipticum Gaud., var. gracilius (Skotts.) Deg., Fl. Haw. 100: 10/4/37.
- S. ellipticum Gaud., forma physophora Deg., Fl. Haw. 100: 10/4/37.
- Holotype: Iles Sandwich, Voyage of the Uranie, 1817-1820, [Wahau, C. Gaudichaud]. (P)?
 Range: Laysan; Kauai to Hawaii.
- Discussion: All the investigators have considered this a variable group. From it there have been

described three species and five variations. Each new revision has produced a different number and grouping of the taxa. The latest, Stemmermann (1981: 49-51), accepted S. ellipticum Gaud. as the inland, erect kind. The marine littoral shrub with broader, succulent blades, she accepted as var. littorale (Hbd.) Skottsbo. The latter is the most easily defined extreme of the population. A careful and comparative study of this broad group was made by Egler (1939). He concluded that it was a single variable species which at the sea beach was a low shrub with fleshy leaves, but further inland was progressively taller and with longer petioles, thinner leaves. The present writer had made similar observations of the littoral bushes and of the taller plant inland, up to 2,000 feet altitude or more, where it forms a small tree. He also comes to the same conclusion, that the best classification of the group is as a single species, S. ellipticum.

Santalum Freycinetianum Gaud., Voy. Uranie Bot. 442, 1829; Atlas t. 45, 1926-1830.

S. Freycinetianum, var. longifolium (Meurisse) Deg., Fl. Haw. 100: 8/6/37.

S. longifolium Meurisse, Linn. Soc. Paris, Bull. Mens. 2: 1,026, 1892.

Holotype: Iles Sandwich, Voy. Uranie, 1817-1820, [C. Gaudichaud], (P).

Range: Oahu, and apparently Molokai.

Santalum haleakalae Hbd., Fl. Haw. Is. 300, 1888.

Holotype: Maui, Haleakala, July 1858, W. Hillebrand (B), specimen now destroyed. Isotypes (BM, K).

Range: East Maui, middle and upper slopes of Haleakala.

Santalum involutum sp. nov. fig. 1.

Diagnosis Holotypi: Arbor glabra est, petiolis 9-17 mm longis, laminis 7.5-9.4 × 1.4-1.8 cm coriaceis lineari-ellipticis integribus subacutis in basi gracile cuneatis lateribus involutis, cymis 3-5 cm longis 9-15-floriferis, pedicellis 1-4 mm longis, floribus (siccis) 9-11 mm longis tubo cylindrico lobis 4 mm longis, drupis vivis 25 × 14 mm.

Diagnosis of Holotype: Trees to 6.6 m tall, glabrous; bark rather smooth, charcoal-colored; petioles 9-17 mm long, reddish; blades 7.5-9.4 × 1.4-1.8 cm, coriaceous, linear elliptic, entire, subacute, the base slenderly cuneate, the sides inrolled so that the blade appears tubular, above olive green, below pale green, lateral



Fig. 1 *Santalum involutum* St. John

veins inconspicuous; cymes terminal, 3-5 cm long, 9-15-flowered; peduncle 9-16 mm long; pedicels 1-4 mm long; flowers (dried) 9-11 mm long (14 when fresh), the perigonal tube cylindric, 5 mm in diameter, greenish yellow, the 4 lobes 4 mm long, (5.5 when fresh); drupes 18-20 \times 8-10 mm, (25 \times 14 when fresh), ellipsoid, angular, including the 3 mm apical cupulate rim.

Expanded Description: Trees 4-8.3 m tall, 15-35 cm in diameter; blades 1.4-1.8 (-2.7) cm wide; cymes 5-15-flowered; drupes 15-20 mm long, the beak 3-5 mm long.

Holotypus: Hawaiian Islands, Kauai Island, between Ke'e and Hanakapiai, ridge top on n. e. side of last stream n. e. of Hanakapiai, dryland forest, with Metrosideros, Acacia Koa, Elaeocarpus, Dicranopteris, 1,000 to 1,200 ft alt., July 25, 1976, Charles Christensen 38 (BISH).

Specimens Examined: Hawaiian Islands, Kauai Island, Napali Coast, ridge e. of Hanakapiai Stream, dryland forest of Diospyros ferrea, 800-1,200 ft alt., Aug. 28, 1976, Christensen 57; crest of Waioli-Waipā Ridge, in koa forest, 1,100 ft alt., Oct. 18, 1976, Christensen 69; Wainiha Valley, 1 1/8 mile in from last house, wet hillside, 650 ft alt., Jan. 21, 1977, Christensen 121, Lumahai-Wainiha Ridge, side of ridge, 1,000 ft alt., April 9, 1977, Christensen 182; near Kalahu, Kalalau Valley, Feb. 1, 1950, O. Degener & Wm. Hatheway 21,369; Wainiha Valley, dry lower forest, 400 ft elev., Jan. 1, 1934, H. St. John & F. R. Fosberg 13,946. The above are all in (BISH).

Range: Kauai, north coast from Wainiha to Kalalau, in the lower forests at from 400 to 1,200 feet altitude.

Discussion: S. involutum has as its closest relative S. majus St. John, of Kauai, a species with the petioles 6-8 mm long; blades 1.7-3.7 mm wide, elliptic, flat; cymes axillary, 4-5.5 cm long, 7-9-flowered; flowers (dried) 16-19 mm long, the lobes 5 mm long; and the drupes 13 \times 10 mm. S. involutum has the petioles 9-17 mm long; blades 1.4-1.8 (-2.7) cm wide, linear elliptic, the sides much involute; cymes terminal, 3-5 cm long, 9-15-flowered; flowers (dried) 9-11 mm long, the lobes 4 mm long; and the drupes 18-20 \times 8-10 mm.

The new epithet is the Latin adjective involutus. inrolled, and it is given with reference to the posture of the leaf blades.

Santalum lanaiense (Rock) Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 21, pl. III, 1916.

S. Freycinetianum Gaud., var. Lanaiense Rock, Indig. Trees Hawaiian Is. 129, 131, 1913.

S. Freycinetianum Gaud., var. *auahiense* Stemmermann,
Pacif. Sci. 34: 45-47, fig. 1, (1980) = 1981.

Holotype: Lanai, on spur of the main ridge, Lanai-hale, about 3,000 ft. elev., July 1910, J. F. Rock 10,061 (BISH).

Range: Lanai, on the slopes from 300 to 1,000 feet, and on the mountain to 3,000 feet altitude; lower middle slopes of east Maui, especially at Auahi.

Santalum majus sp. nov. fig. 2.

Diagnosis Holotypi: Arbor 4-5 m alta glabra est, petiolis 6-8 mm longis, laminis 6.1-8 X 2.6-3.5 cm. subcoriaceis ellipticis petiolis acutis basi rotundata, cymis axillaribus 4-5.5 cm longis 7-9-floriferis, floribus siccis 16-19 mm longis lobis 5 mm longis ovatis acutis vel late lanceolatis, drupis 13 X 10 mm ellipsoid-eis.

Diagnosis of Holotype: Tree 4-5 m tall; herbage glabrous; petioles 6-8 mm long; blades 6.1-8 X 2.6-3.5 cm subcoriaceous, elliptic, flat, entire, the apex acute, the base rounded, above dark green, below green, the lateral veins inconspicuous; cymes axillary, 4-5.5 cm long, 7- or 9-flowered; peduncle 10-18 mm long; pedicels 2-3 mm long; flowers (dried) 16-19 mm long, 3 mm in diameter, the perigonal tube green, the 4 lobes 5 mm long, ovate and acute or broadly lanceolate, within greenish yellow to red; stamens 4; filaments 2 mm long, subulate; anthers 2 mm long, ellipsoid; style 10 mm long; stigma lobes 0.7 mm long, rounded; disk lobes 3.5 mm long, the apex globose, puberulent; drupes 13 X 10 mm ellipsoid, and at apex with a cupulate rim 1.5 mm high and 4.5 mm in diameter.

Expanded Description: Trees 20-30 cm in diameter; blades 6.1-9 X 1.7-3.7 cm; flowers 16-20 mm long, the lobes 5-6 mm long.

Holotypus: Hawaiian Islands, Kauai Island, Kumuwela Ditch Trail, along border between Kokee State Park and Na Pali-Kona Forest Reserve, 3,600-3,800 ft elev., 13 Aug. 1964, M. R. Crosby & W. R. Anderson 2,024 (BISH).

Specimens Examined: Hawaiian Islands, Kauai Island, Awaawapuhi Trail, Kokee State Park, July 17, 1970, D. Herbst 6,515; Helemanu forest, Feb. 14-26, 1909, J. F. Rock 1,834; Milolii Ridge, Waimea, open koa forest, 2,050 ft alt., Dec. 27, 1933, H. St. John & F. R. Fosberg 13,753; Kokee, vicinity of forest ranger station, transition between wet and dry forest, 3,500 ft alt., Aug. 1961, W. L. Stern & S. Carlquist 1,278. All the above are in (BISH).

Range: Kauai, Kokee region, 2,050 to 3,800 feet alt.

Discussion: The closest relative of *S. majus* is

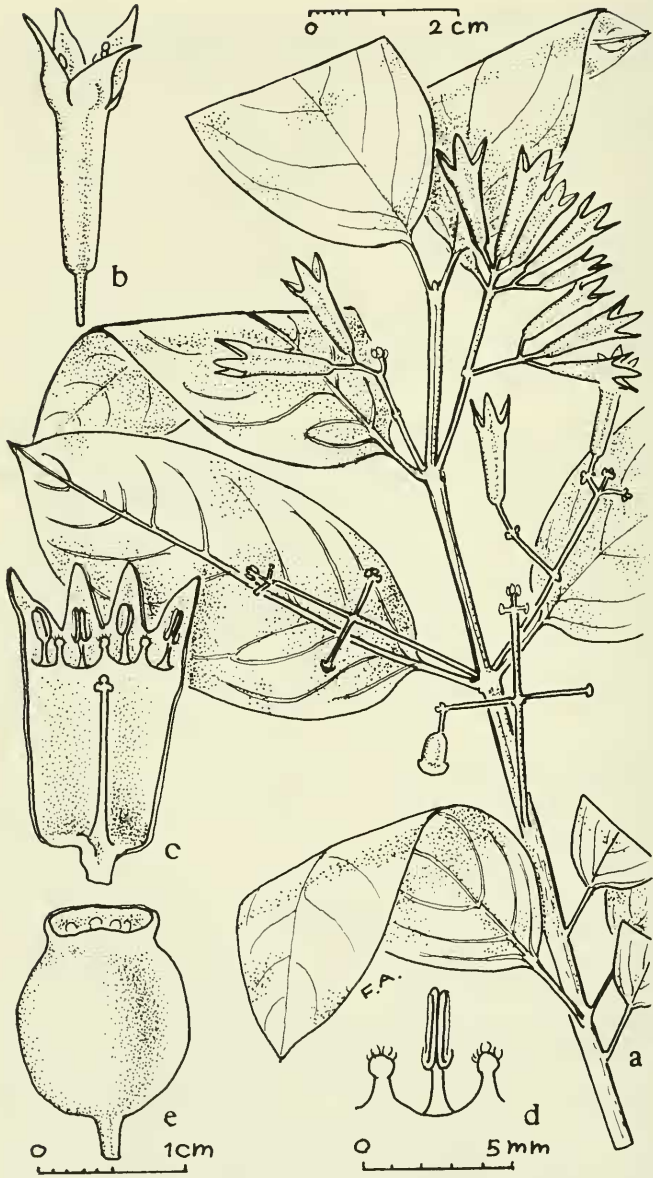


Fig. 2

Santalum majus St. John

S. involutum St. John, and under the treatment of that species the contrasting characters are stated.

The new epithet is the Latin comparative adjective, *majus*, larger, and it is used with reference to the larger size of the leaf blades.

Santalum paniculatum H. & A., Bot. Beechey Voy. 94, 1832, var. *paniculatum*.

S. Pilgeri Rock, var. *luteum* Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 31, pl. IX, 1916.

S. ellipticum Gaud., var. *luteum* (Rock) Deg., Fl. Haw. Is. 100: 10/4/37.

S. ellipticum, var. *annectens* Deg., Fl. Haw. Is. 100: 10/4/37.

S. ellipticum, var. *chartaceum* Deg. & Deg., Phytologia 27: 145, 1973.

Holotype: Ins. Sandwich, Hawaii, near Kilauea, Maio 1825, *Macrae* (K).

Range: Hawaii, slopes of Mauna Kea, Mauna Loa, and Hualalai.

S. paniculatum H. & A., var. *Pilgeri* (Rock) Stemmermann, Pacif. Sci. 34: 52, (1980) = 1981.

S. Pilgeri Rock, Hawaii Bd. Agr. For., Bot. Bull. 3: 29, pl. VIII, 1916.

Holotype: Hawaiian Islands, Hawaii Island, Pulehua above Kealakekua, on aa lava flow, 5,000 ft elev., Feb. 10, 1912, *J. F. Rock* 10,033 (BISH).

Range: Hawaii, woods of North Kona, and South Kona.

Santalum pyrularium Gray, A. Acad. Arts Sci., Proc. 4: 326-327, 1860.

S. Freycinetianum Gaud., var. *pyrularium* (Gray) Stemm., Pacif. Sci. 34: 48, (1980) = 1981.

Holotype: Sandwich Islands, Kauai, *Wilkes Expedition* (US).

Range: Hawaiian Islands, Kauai Island, moist forest on the mountains.

S. pyrularium Gray, var. *sphaerolithos* Skottsberg., Göteborg. Bot. Trädg., Meddel. 15: 359. figs. 294-295, 1944.

Holotype: Hawaiian Islands, Kauai Island, trail from Lehua makanoe to Kilohana, 16/8/38, *L. M. Cranwell & C. Skottsberg* 2,979 (BISH).

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Legend

- Fig. 1. Santalum involutum St. John, from holotype.
a, habit, X 1; b, bud, X 2; c, fruit, X 2.
- Fig. 2. Santalum majus St. John, from holotype.
a, habit, X 1; b, flower, X 2; c, flower, cut open, X 2;
d, stamen and disk lobes, X 4; e, fruit, X 2.